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(54) PULSE-SUPERVISED MULTI-VEHICLE ELEVATOR SYSTEM

(71) We, WESTINGHOUSE ELECTRIC CORPORATION, of 3 Gateway Center, Pittsburgh, Pennsylvania, United States of America, a Company organised and existing under the laws of the Commonwealth of Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to supervisory control of elevator systems employing several vehicles.

The British Patent Specification No. 1,196,981 describes in detail certain features of a solid state pulse-supervised elevator control system which are also necessary to complete the detailed description of the supervisory system which is the subject of this invention. In order to avoid duplication and limit the complexity of this application, this aforesaid Specification No. 1,196,981 is hereby incorporated by reference into this application and should be referred to for those circuits not described herein which are necessary to complete a working embodiment of the invention. That Specification will henceforth be referred to as the "incorporated Patent".

One of the primary objectives in the design of elevator supervisory systems is to achieve efficient utilization of the cars while providing equitable service for both car and corridor calls. Since the advent of multi-car systems various schemes have been proposed to achieve this objective. One line of approach has been the various quota systems. Such systems are concerned with two problems; the number of cars in service and the distribution of calls between the cars in service. United States of America Patent No. 2,057,480 is primarily concerned with the first of these problems in that if the total number of calls in the system (corridor calls only) exceeds a predetermined number per car in service, another car is put into service. United States of America Patent No. 3,379,284 proposes a supervisory system which is also primarily concerned with bringing cars into service. If there are more than two corridor calls in front of a car traveling in a given direction, an idle car behind is started to help out.

United States of America Patent No. 2,104,522 is an example of the proposed systems which deal with the distribution of calls between the cars in service. According to Jones, a fixed number of corridor calls ahead of a particular car are specifically assigned to that car. The corridor calls ahead of the car are assigned in chronological order as registered and only the car specifically assigned to a corridor call can stop for it. Since the cars are irrevocably assigned to specific calls, such a system lacks flexibility and can lead to inequitable

call signals and corridor call signals in the order of the landings alternately in the up and down directions. The allocation of calls is made on each scan in each direction. On the down scan calls are allocated to cars serving in the down direction while on the up scan calls are allocated to cars serving in that direction. Since the scanning sequence is so rapid, calls are continually allocated according to the existing traffic situation. As calls are answered, new calls are registered and new cars are assigned, the allocation of calls is updated. It should be understood that cars are not restricted to answering only calls allocated specifically to them. In fact, cars will stop for all corridor calls for service in the direction in which they are serving unless they are restricted from seeing the corridor call under circumstances described above or the system selects the car to bypass corridor calls as would be the case for instance where the car was substantially fully loaded. The allocation of calls is primarily utilized in determining whether the number and distribution of cars serving in the direction of scan is adequate under the existing traffic situation. In the preferred embodiment of the invention sequential digital counters are utilized in the allocation circuits.

In assigning available cars to serve a demand for an extra car the system selects the closest available car to the demand. On each scan the scanner notes the relative positions of available cars. If a demand is also seen on a scan the closest car is selected and dispatched to serve the demand. The system accomplishes this by remembering the position of the last available car detected by the scanner and by measuring the distance between it and a demand. Once a demand is detected the system begins measuring the distance between it and the next available car. If the scanner scans the same distance past the demand as the first available car was before the demand without seeing another available car, the first car is necessarily the closer and is started immediately. If the scan is completed before a second available car is seen the first available car is again the closest car. If a second available car is detected after the demand and this car is closer to the demand than the available car seen before the demand was, it is started as soon as the scanner reaches it, if the scanner detects the second available car before it detects the demand, measurement of the first distance is reinitiated. If the scanner detects the demand before an available car, the first available car seen is obviously the closest and can be started immediately. If the two available cars are the same distance above and below the demand either car could be selected. The preferred embodiment of the invention selects the second car detected which would be the car below the demand for down corridor calls and the car above the demand for up corridor calls. When two available cars are at the same floor, the system selects one of them on a random basis. When the scanner detects an available car at the same floor as the demand, it is obviously the closest and the doors are opened. In the preferred embodiment of the invention, the distance is measured by digital counters which count landings between available cars and demands. In special circumstances where the distance between landings is not uniform, as for example in the case of an express zone, extra counts can be inserted into the counters. For the purpose of assigning available cars to serve demands according to the method of this invention, only one demand is recognized on each scan in each direction.

Cars can become available even if there are calls ahead of them in the direction in which they were serving if other cars are in position to serve those calls. For instance, when a car has answered its last car call and there are no corridor calls for service in the direction in which it has been serving between it and the next preceding car serving in the same direction, the car will be made available. However, under certain circumstances, even though there are no corridor calls between the car and the preceding car serving in the same direction, the car will not stop and become available. Such circumstances include the situation where the next preceding car has its quota of calls allocated to it and the last call so allocated is a corridor call. Another such situation is where even though the next preceding car has not been allocated its quota of calls, the second preceding car has more than a quota of calls ahead of it and at least one of these is a corridor call. In either of these situations, the trailing car can very likely reach a corridor call before one of the preceding cars and therefore it is not desirable to have it stop and become available.

Cars become available at the completion of a scan in the direction in which they were serving, so that if demands in both directions are registered when a car becomes available, demands in the direction opposite the direction in which the car was serving will be given preference. This priority in the assignment of available cars to demands assumes equitable service during periods of heavy traffic.

One advantage of the rapid scanning sequence utilized in this invention is that simulated alternative car distribution patterns can be considered on selected scans

without effecting the operation of the cars. If the alternative pattern would better serve the existing calls, the cars can be shifted in accordance with the alternative pattern. Specifically, this can be applied to releasing a car serving in one direction to serve a demand in the opposite direction when there are no available cars for assignment. When a demand in one direction exists and no cars are available, the lead car in the opposite direction is blanked on the next scan. The corridor calls that would normally be allocated to the lead car are therefor referred back to trailing cars. If this does not result in leaving a demand in the opposite direction in front of the other cars serving in the opposite direction, then the lead car will be stopped at the next floor it comes to as long as no car calls are registered in the car. When a car is stopped under these circumstances, the doors are not opened and the car becomes available as soon as it stops.

Since as mentioned, the cars are made available at the completion of a scan in the direction in which they were serving, the car which is made available will be assigned to the demand in the given direction. This will be done even if there is a demand for service in the opposite direction. If the demand in the opposite direction is behind all the cars serving in the opposite direction they of course can do nothing about it. Removing one car from service does not affect this demand. The real concern is with whether the car is needed to do what it is doing or can it better serve other purposes.

In other words a pulse supervised multi-car elevator system is provided wherein a predetermined number of car and corridor calls are allocated to the closest car behind the corridor call serving in the direction of the corridor calls. Excess calls in front of a car are referred back to trailing cars serving in the same direction. Calls not allocated to cars serving in the direction of the corridor calls create a demand for an extra car to be assigned.

U.S. Patent No. 3,256,958 describes an elevator supervisory system wherein an artificial demand is created at the lower terminal floor when no car is located there and none is traveling in the down direction. No demand for an additional car is created if a car is traveling in the down direction on the assumption that the car will reach the lower terminal floor shortly. This is not true however, if the down traveling car is near the top of the building or no matter where the car is located, if it has numerous stops to make before reaching the lower terminal.

The system described in the last mentioned patent gives preference for the assignment of available cars to zones in which calls have been registered for a period of time in excess of a predetermined interval. According to that invention one car is irrevocably assigned to serve corridor calls in the direction of the timed-out corridor call in the zone in which such call is registered. Only one car can be assigned to serve calls in the direction of the timed-out call in the associated zone regardless of the number of corridor calls registered therein.

Designers of prior art elevator supervisory systems have devoted a great deal of attention to reducing the length of time that a prospective passenger must wait for a car. The prior art systems; however, do not consider the length of time that a passenger spends in transit once he has boarded a car. Since a passenger is primarily interested in arriving at his destination as quickly as possible, the transit time in addition to the waiting time should be considered in designing the elevator supervisory system.

In the preferred embodiment if no car is located at the lower terminal floor, a demand is created to dispatch a car to that floor unless there is a car serving in the down direction in the lower portion of the building which has a predetermined number or less of stops to make. The assumption here is that if the car is close to the main floor and does not have an excessive number of stops ahead of it which would delay its arrival at the main floor, there is is no reason to assign another car to the main floor. In the preferred embodiment of the invention the predetermined number of stops is considered to be ONE which, in the normal course of things, would be the car call registered by the passenger within the car for the lower terminal floor since most down traveling passengers exit at the lower terminal. Little is lost if the passenger gets off at a floor above the terminal floor, since when the passenger departs the car will become available and can be immediately assigned to descent to the lower terminal.

If no car is traveling down in the lower portion of the building with only one stop ahead of it, the artificial demand at the main floor will be registered. This demand will be registered as an up demand at the lower terminal and the car assigned to it will therefore necessarily travel down to serve the up demand. If the assigned car detects any actual up corridor calls between it and the lower terminal floor, it will ignore the artificial demand at the lower terminal and will reverse at the lowest actual up corridor call. If a prospective passenger has registered an actual up corridor call at the